

Collecting Economic Rents on North Sea Oil and Gas: A Proposal

(Edited Research Report submitted to ESRC)

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1. Summary of Research Results

The question of the right level of taxation for extraction industries in general and North Sea Oil in particular is complex both in terms of economic theory and political economy. North Sea oil is sought, found, developed and produced by private sector oil companies. The early history of the industry was characterised by significant specific taxes - petroleum revenue tax (PRT, an additional corporation tax payable after investment costs had been recouped), royalties per tonne of oil extracted, plus supplementary petroleum duty (introduced in 1981) and, when government finance was in special need, an advanced payment of PRT (APRT). The government then decided that the tax level was discouraging further exploration and development and most of these specific taxes were withdrawn or diluted in 1983. When PRT was abolished in 1993, the only real tax on the North Sea oil and gas industry was standard corporation tax, at the rate levied on all corporations in all sectors of the economy. It is claimed that there has been a response to these tax reductions in terms of increased activity in the North Sea, although one should recognise that other advantages for North Sea operations may also have been partly responsible, for example relative political stability.

The Labour Government in the UK did initially consider carrying out a review of tax policy for North Sea oil and gas operations. The fall in oil prices meant that the review did not take off, but the recent resurgence of oil prices to levels not seen for a decade has brought the prospect of an active policy much nearer. There exists strong public opinion that oil companies make too much money and should pay more tax.

Based on the research described in the main report, we have come up with a set of recommendations for reform in the North Sea fiscal regime (see Table below).

The status quo against which any reform proposals must be judged is what may be described as a "beauty contest" (column 4) with no bidding for licenses to explore and develop oil tracts.

Proposal 1 Reimposition of PRT/RRT

It seems to us that PRT was a relatively neutral and fairly efficient way of recouping the economic rents arising from North Sea oil and gas production. Our first proposal for restoring tax efficiency is to reinstate PRT (or RRT) at a rate of 50% for all fields and not only those that filed their development plans before 1993.

	<i>Proposal 1</i> (No competition)	<i>Proposal 2</i> (Partial competition)	<i>Proposal 3</i> (Full competition)	<i>Status Quo</i> (Beauty contest)
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Fiscal Regime	No auction but PRT/RRT reinstated	Auction of Licenses Plus PRT/RRT	Auction of licenses with share bidding	
Exploration	No price bidding	Price bidding	Share bidding	No price bidding
Development /Production	PRT/RRT rate 0.5	PRT/RRT rate 0.5	Share retention or sale option $s \geq 0$	No PRT/RRT

Notes: corporation tax is payable throughout, rate of PRT/RRT is the one currently charged for fields with development approved before 1993. RRT, resource rent tax, is like PRT except that interest payment for capital costs is tax deductible.

Proposal 2 Auction of Licenses Plus PRT/RRT

To replace the beauty contest by a multi-unit auction of oil tracts, with simple price bidding. This would permit a differential government revenue across tracts over and above the progressive nature of the PRT or RRT tax.

Proposal 3 Auction of Licenses with Share Bidding

While the first proposal is for a return to previous practice, the second adds an element of competition. The third proposal, being a substantial revision of the fiscal regime in the North Sea, is described in more detail. Like proposal 2, it is a combination of an auction mechanism and tax levy, but the auction is not ascending price bidding. It is descending share bidding, with the winning bidder leaving the largest proportion of the equity with the Government. So no initial financial outlay is required by the winning bidder. As the proceeds of a successful tract are shared with the government: there should be no regret felt by the government (and the electorate) when the oil price surges and oil company profits rise. The government may nevertheless sell its share at any time if it so wishes.

Such an auction permits the equity share left with the government to vary from tract to tract or license to license according to the relative desirability of the field. It thus gives an allocation mechanism which leaves the highest government equity stake in the best licenses. In many ways the equity stake is similar to a profit tax. However, while the rate of profit tax is common across firms' operations, the equity share reflects initial expectations of profit. With any element of non-neutrality (for example risk aversion, non-complete tax offset of losses, etc.) a given profit/revenue tax determines the minimum expectations necessary for a firm to develop a tract and hence identifies the marginal active tract. A share-bidding mechanism, starting with zero share with the government, would imply efficiency in that development of any tract, which was profitable if no equity share was lost to the government, would be implemented.

Clearly a base level of PRT or RRT can also be in place: this would just ratchet down the government's equity share for a given amount of competition. Multiple licenses could be auctioned by an open auction with constraints on bidding activity similar to the FCC spectrum auctions. Competition can be promoted by enforcing rules on non-collusion, again as have been proved successful within the spectrum framework.

2. Full Report of Research Activities and Results

Background

In the 1990s, hydrocarbon production from the UK North Sea Continental Shelf is booming while the tax take is dwindling. Production levels in 1990s exceed those in 1980s and are forecast to continue at or above the current levels for the near future. But the government tax take from oil and gas production has declined substantially. This could be due to many reasons such as the fall in the oil price, the major round of secondary development, many mature fields towards their end of life and development of new fields which have not generated sufficient revenues. However, in the 1993 budget, Petroleum Revenue Tax (PRT) was reduced from 75% to 50% on the existing fields and abolished completely for new fields. This poses a question of whether a UK fiscal regime applied to the North Sea oil industry could extract appropriate share of economic rents if and when oil prices rise or new fields come to stream.

In his paper, Zhang (1997) examined the tax efficiency and economic neutrality of a PRT based tax regime in the context of volatile oil prices. He concluded that pre-1993 regime was relatively efficient in collecting economic rents without causing significant distortion to the development decision. So if profits and production continue at or above current levels, one option open to the government would be to reintroduce PRT.

The objective of the project is to look at two alternative possibilities that might be considered. The first of these is the imposition of the Resource Rent Tax (RRT) along the lines originally proposed by Garnaut and Clunies Ross (1975); the second is that of selling petroleum leases by auction, as is the practice in the USA for example.

Objectives

The objectives outlined in our application included:

1. Using the real options approach to study the effect of a resource rent tax (RRT) on the development decision when future oil prices are uncertain.
2. Using game theory to investigate auction mechanisms which could be applied to North Sea oil development.
3. The output should certainly include theoretical results comparing PRT and RRT in the face of oil price uncertainty; and for auction design in this area.
4. Based on the findings, we are to frame a proposal for a neutral and efficient regime for collecting rents on North Sea oil and gas.

These objectives been addressed both by research papers and a proposed edited volume as follows:

1. In Chapter 4 of the edited volume, we compare the effect of PRT and RRT on development of the oil fields using the real options approach. Under comparable conditions, we show how a RRT which involves smaller up-front allowances can be more efficient than PRT in collecting economic rents.

The neutral tax itself may not guarantee that developments would not be distorted. In Miller and Zhang (1999), we show how state contingent taxation can sharply reduce the value of waiting and increase the firm's incentives to preempt the fiscal authorities by accelerating

developments. In the presence of such incentives for tax avoidance generated by state contingent fiscal regimes, we argue for establishing a stable and neutral tax system.

2. Two chapters of the proposed book consider key issues in the application of auctions to oil tract allocation. Chapter 7 considers the sale by an auction mechanism of multiple units where each unit is sold to disjoint sets of bidders but there are cross effects on the value placed on one unit according to the outcome of the sale of other units. These cross effects may be particularly relevant in the allocation of sets of oil tracts where cooperation opportunities in sharing some extraction costs may vary with the developers' identities. Chapter 6 argues that a bidding system in terms of an equity stake being retained by the government may have substantial advantages. Both sets of argument are strands in the case to use auctions to obtain part of the oil and gas rents, and can be seen as additional to other rent-extraction devices such as special tax regimes.

3 and 4. To tackle these objectives we have produced a first draft of a book containing research results on both oil taxation and auctions.

Methods

To analyse strategic behaviour in auctions of petroleum leases, *game theory* techniques were used to assess the efficiency of the auction processes in the presence of significant network benefits to the bidders or of a natural temporal structure in the process of production.

In studying the impact of PRT and RRT on the development decision, we employ the modified *real options model* used in Miller and Zhang (1997) and Zhang (1997), which is tailored particularly to look at the effect of taxation under oil price uncertainty.

Results

1. Introduction

Successive changes in the UK North Sea fiscal regimes have made it one of the weakest oil tax regimes in the world (second only to Ireland), Rutledge and Wright (1996). Taxes have been reduced or ended as follows:

In 1983 Royalties were abolished on new fields and a process of phasing out Advanced Petroleum Revenue Tax was begun. ... Meanwhile corporation tax was steadily being reduced from 52% at the time the North Sea began full development down to 33% today: lower than the USA and other European countries. Finally, in the 1993 budget, PRT was reduced from 75% to 50% on existing fields and abolished completely for new fields (now called 'non-taxable' fields). ... (Rutledge and Wright, 1996)

For fields developed after 1993, only Corporation Tax at 33% is payable. Consequently, in 1997, when the oil price was about \$20 per barrel, it was widely expected that the incoming Labour Government would reintroduce taxes to recoup economic rents on North Sea oil in the 1998 budget. But, when the oil price plummeted to a little over \$10 per barrel, these plans were shelved. This has led the practitioners in oil industry to believe that the current regime is unstable in that taxes could be introduced in the future if and when oil prices are sufficiently high (Petroconsultants, 1995, pp9, 15). What kind of taxes might be implemented?

The obvious candidates are those previously levied, namely PRT and Royalties. PRT levied on the North Sea oil fields had a very high marginal tax rate but allowed the operating profits to be deductible against the development cost plus an up-lift. Royalties are a straightforward levy on revenues with no allowances and are therefore distortionary. Each of these taxes has its supporters. Mabro (1994, FT, Dec. 11), for example, advocated the reinstatement of Royalties. According to him, not to have Royalties is “as if the Government handed out buildings rent-free to business and simply charged them corporation tax on their profits”. On the other hand, Zhang (1997), using a real options approach, showed that pre-1993 PRT was basically neutral and efficient in collecting most of the economic rent, and proposed that the future fiscal regime should include a tax similar to PRT --- corrected for disincentive effects on secondary development. To the best of our knowledge it is unclear what kind of tax will be implemented as and when profitability returns to industry.

2. PRT and state contingent taxes

In the paper it is assumed that PRT will be reintroduced at a given revenue trigger and the shift of the tax regime is irreversible. At first blush, it might seem that if the tax is neutral, its expected implementation would be of no consequences; while expectations of a distortionary tax would defer development. Neither of these predictions are correct: they ignore the incentive facing oil companies to preempt the fiscal authorities by developing early. Two main results are reported. First, anticipations of a neutral tax regime are typically not neutral; development usually takes place earlier. Second, anticipations of a distortionary regime also accelerate development. State contingent taxation sharply reduces the value of waiting, and the incentive to preempt the fiscal authorities accelerates development in much the same way as the incentive to preempt competitors leads to early entry in Lambrecht and Perraudin (1996). The incentives for tax avoidance generated by state contingent fiscal regimes are, in our view, a substantial argument for establishing stable tax system, preferably one that is neutral.

While the paper focuses on the strategic behaviour of the oil companies, it has neglected two aspects of strategic behaviour of the government. First it is assumed that the government is not behaving strategically in its choice of the trigger for re-implementing taxes; that may be an over-simplification. Second the formal analysis treats all net oil revenues as pure rent --- so rate of PRT can be set very high. But this conclusion needs to be qualified in an environment of global “tax competition” where resources may be relocated elsewhere. So the fiscal regime chosen needs to be “reasonably attractive” to keep development going.

Because of the space limit, we summarise other results on tax implementation from this project in the outline of the book below.

3. Auctions

In virtually all cases, information and incentive problems mean that tax regimes have to treat all affected agents in a symmetric way. Although a successful firm may pay more corporation tax than a less successful firm, this does not occur because the latter is in a different tax regime - rather that a single tax regime taxes high incomes more (and indeed sometimes proportionately more) than lower incomes. An associated issue to the common fiscal regime of all licenses relates to the heterogeneity of oil tracts and whether the government should not seek to obtain the best possible revenue from a tract that is more promising than another, that is when some licenses are more valuable than others.

When exploration licenses are allocated, taxing successful outcomes and not unsuccessful outcomes may provide insurance to the contracting firm, but what if ex ante some licenses are deemed more likely to be successful than others? Then contractors will all prefer the most promising licenses. A random or other "fair" allocation (e.g. rotation or a beauty contest based on capacity and location of existing fields) will be necessary to ensure equal treatment across companies and thus full participation when tax rates remove most of the rents. The difference in possible rents of the better licenses compared to the others is not recoverable by the government except as part of a non-transparent bilateral negotiation (e.g. if you explore here then we will let you explore there).

A market in licenses might offer the opportunity for the government to gain some of the rents from these quality differences in a clear and objective way. At the same time, a market permits a higher price to be paid for licenses when, say, the oil price is expected to be high than at other less optimistic times. Thus the role of selling mechanisms is not to displace taxation in the extraction of rent but rather to

- (i) allocate each license to the contractor willing to pay most for that particular license;
- (ii) extract for the government a substantial part of the differential rent offered by promising rather than unpromising licenses, and by licenses sold at times when they are more highly valued.

A market for new licenses thus permits variations in tract quality across tracts and across time to be ironed out without the need to significantly change the fiscal system in operation.

A number of de facto principles relating to the UK position also need to be acknowledged. First, the government requires the exploration costs to be met by the private sector, since government perceives that monitoring exploration is costly and difficult. Second, exploration firms would face additional risk within a very risky operational environment if they had to pay substantial sums to the government in advance of the outcome of the exploration. Finally, the government puts large store on the tracts made available actually being explored and developed. Thus the use of reserve prices of any kind and more generally the use of optimal mechanisms which are not always efficient is unlikely to be acceptable. Chapter 6 has put forward a broad theory that arguably can be adapted to offer a solution to all these requirements. It is based on a simple auction where bids are in the form of shares of the exploration company. The auction outcome does not affect the cost allocations between public and private sector, but does allow differential rent extraction according to the promise of each oil tract, both at the time it is sold for exploration and at the development stage. This is seen as an open auction and is also capable of extension to the case where multiple tracts are being allocated simultaneously. Chapter 6 demonstrates some of the concerns of an optimal mechanism for allocations when each tract is to be developed by a different company. The complexity of these mechanism probably imply that an open simultaneous auction adapted from the spectrum auctions developed by the Federal Communications Commission (FCC) in the mid 1990s is the more interesting path to investigate (See Bulow and Klemperer, 1996 for a discussion of the limits to be gained from an optimal mechanism).

3.1. The Advantages and Disadvantages of Auction Mechanisms

The sale of the radio spectrum in the USA was a path-breaking application of a simple mechanism of an open auction. There seems to be no reason why the same approach should not be applied to licenses in the oil sectors and to those in the UK. It is currently being very successfully applied by the UK government to sell third-generation mobile telephone spectrum licenses. The essentials of this auction mechanism applied to the sale of licenses would be as follows

- (i) a number of licenses are available and in each round the contractors can bid for any number of licenses (alternatively restrictions can be put in place). For each license, a new bid has to exceed the previous highest bid by a given margin.
- (ii) a bid can be withdrawn by payment of a significant but small penalty.
- (iii) when no further bids are made or withdrawn, no more rounds are undertaken and the allocation is made: each license is allocated to the highest bidder and the winning bid is collected by the government.

The properties of this auction include

- (i) The opportunity to group winning bids to the bidder's advantage. In particular to bid strongly for the licenses which the bidder is best placed to develop. Complementary factors (e.g. who is likely to develop a neighboring tract) can also be taken into account (see Chapter 7).
- (ii) The opportunity to retreat from one license when it is clear that another bidder is determined to gain other (for example neighboring licenses) without which that license is unappealing.
- (iii) Since in general bidding will not stop until no bidder would be better off placing a higher bid than the current winning bid, the outcome is likely to be at least broadly efficient.
- (iv) In the absence of a minimum bid requirement, all licenses with a positive value will be taken up.¹

The difficulties of this auction relate to

- (i) The possibility that bidders will collude and restrict bids to minimal amounts and that this would replace a government-orchestrated allocation procedure with an industry one.²
- (ii) The possibility that the number of bidders may be reduced by the existence of bidder costs. That is that the bidder costs may be sufficient to deter entry into the auction.
- (iii) Possible loss of control over features of the exploration, eg timing and criteria for abandonment, compared with a centralised allocation method. Note that the government claims to have consistently maintained a policy of "hands off" over all operational questions; however the ongoing central allocation of the current system permits the government to control operators by (the threat of) withdrawing future allocations.

¹ It would certainly be within the spirit of UK policy towards the North Sea oil and gas sector that there should be no reserve price. Certainly, it is considered of paramount importance to have all tracts offered taken up. In the US outer continental shelf allocations some highest bids are not taken up, and the reservation price is generally unknown to bidders. Such a mechanism is not considered here but see Hendricks et al (1994). See Ireland (Chapter 6) for a more general and detailed analysis of auctions by bidding shares.

² Porter and Zona (1993) discuss the detection of bidding rings in sealed bid auctions. Basically provided not all bidders are within the cartel evidence of collusion can be built up. Again, in an open auction outsiders can make large gains if the cartel is not complete, and any attempt to manage the auctions so that the cartel members take turns to win should become clear.

(iv) Quality thresholds of license operation may have to be set so as to ensure that successful bidders do not abuse their positions, for example by creating pollution or safety problems, or by delaying active exploration.³

3.2 Share-bidding Auctions

The selling of licenses in an open auction could be presumed to take place before exploratory drilling. It may be considered that in fact the differentials in value are much higher after the exploration has been undertaken and better information as to the commercial viability and quantity and quality of oil or gas has been obtained. There exists the possibility that the government should incorporate an allocation mechanism at the development stage in addition to the exploration stage. The essential reason is that the market for equity in successful oil finds is likely to be reasonably competitive. The government has the choice of selling to a number of diverse agents or perhaps of selling its rights as a whole to the exploration firm or indeed to another firm. Selling at this stage promises the advantage of a more competitive demand side. The question is how to get the exploration done without using public funds and without relinquishing all rights to any successful find.

A variation using the model of Chapter 6 removes an important possible objection. At stage 1, the oil company is being asked to pay for its shares as well as fund the exploration. This requires a large financial commitment which imposes perhaps too high a level of risk on the company. An alternative is to have the stage 1 bidding in terms of the **share** of the total shareholding granted to the company. Thus the company bidding least shares wins the exploration license. This is a dual problem to the normal ascending bid auction. Instead of the firm winning a given share of the exploration firm by paying the highest bid, it wins control by bidding the lowest share given no cash is transferred. We can argue that such a system is very like competition over the tract-specific tax rate to be levied.⁴ It also reduces the immediate payoff from the illegal formation of bidding cartels, and thus arguably makes these easier to prevent. Finally, it may make it easier, relative to the normal ascending price auction, for the government to commit to not introduce specific taxes in the North Sea sector *after* the auction mechanism since it too will be a shareholder: revenue from selling the shareholding in the second stage may be a source of political status, and would be reduced if taxes were increased. Thus not only would auction mechanisms assist fiscal stability in permitting different treatment of different vintages of licenses, but also a minimum share auction would leave the government with an equity share to be sold in the future and whose value depends on future tax rates. Of course, committed taxation policy simply informs the calculation of expected values of the net operating proceeds from the license, and thus acts as an industry base. Individual license bids make the rent collection sensitive to the heterogeneous expectations across the various tracts on offer.

These comments are made in the knowledge of limited experience and success in using conventional auctions to allocate licenses in North Sea oil and gas. World-wide, oil licenses

³ Quality thresholds may be enforced by production plans being scrutinised prior to bidding or after bidding. Results of Ireland and Cripps (1994) suggest equivalent outcomes for the seller.

⁴ That is the firm willing to pay the highest profit tax on the particular tract is allocated the license. See McAfee and McMillan (1986, 1987) and Riley (1988) for an analogous argument concerning the role of a share in a principle-agent contract. Note that the controlling firm could decide to sell its shares and relinquish control. The shareholding that it has confers some advantages in this (see Bulow, Huang and Klemperer (1999)). However the control itself offers opportunities to signal the quality of the find and may lead to signalling costs which render a change of control inefficient.

are often allocated by auction (generally sealed bid auctions) and the results have been analysed in a series of papers.⁵ It may be that the problem for North Sea oil and gas has been the risk factors involved and that these prevent any considerable revenue return from license sales. Putting the commitment of the firms into the form of equity shares rather than cash and not placing any reserve should be a relatively low cost test of whether this is true or not.

This approach offers the ability to ape license-specific profits taxes, while relying on valuations of licenses by the oil companies themselves, but with the added possibility of drawing in wider financial involvement. The crucial political advantage is that the equity share, while it is retained by the government, means that the state treasury benefits from unanticipated shocks of higher oil prices or improved production technology. It does not have to defend a position of having sold the Golden goose for a pittance. Of course, a number of interesting and pertinent issues have not been included in the model. Some of the more important are risk aversion of the oil companies, joint bids by two oil companies, formation of development companies by trading in shares, more complex tax allowance policies, etc. These extensions are the subject of on-going research.

4. Content of the Draft Book

The research carried out in this project together with other papers we have written in this area have been assembled into a book “Developing North Oil: Investing under Uncertainty”. The book is divided into three parts.

Part 1 Irreversible investment

The opening Chapter provides a general overview of the UK oil industry, beginning with the history and profitability of oil and gas extraction in the UK Continental Shelf (UKCS) and its contribution to GDP. After an account of the fiscal regime(s), government revenues attributable to oil and gas are shown. As a percentage of total UK taxes they reach a maximum of 24% in 1984/5 but fallback to 2% in 1998/9. Proven reserves and production of UK Continental Shelf are compared with those of other oil producing countries around world; and there follows a chronology of oil prices since 1970. Weekly figures of oil prices in more recent times highlight the collapse of oil prices from over \$20 in early 1996 to under \$10 in early 1999, and subsequent surge to almost \$30 a barrel at the beginning of year 2000. The Chapter concludes with a profile of a typical oil field, showing how revenues depend upon prices and production, and how taxes are divided between the Corporation Tax and PRT.

Chapter 2 develops a basic model of oil production, using the real options approach and treating development costs as if they were payable as a lump sum. Assuming extraction declines at a geometric rate and oil prices follow geometric Brownian motion, the trigger prices for extraction and closedown are derived for the case of infinite reserves. With finite reserves, attention is focused on the determining the development trigger for the case with fixed development cost, proportional extraction costs and no close-down.

⁵ A number of papers have considered auctions for tracts in the Americas. Hendricks and Porter (1988), (1992) and Porter (1995) consider the North American Outer Continental Shelf. Porter (1995) in particular gives a very comprehensive analysis of offshore lease sales 1954-90.

The next chapter provides three applications/extensions of this stochastic framework. It is first used to value a floor price contract for oil or gas that has already been developed, and then to solve for the triggers for incremental development and for abandonment. An unexpected finding in the context of these extensions was the crucial importance of the risk factor used in discounting oil profits. In valuing fixed floor price contract for example, it matters greatly whether the alternative (of selling the oil at stochastically evolving market prices) is heavily discounted for risk or not. A floor price contract which cuts off down side risk only increases the value of reserves by 30% for risk neutral oil firms that discount profits at 4%, but this rises to 140% if the risk premium is 6% (i.e., the discount rate is 10%). The floor price contract value rises more than proportional to the discount rate.

Part 2: Taxing Oil revenues and Auctioning Petroleum Leases.

This section, the heart of the book, analyses how the government can raise revenues from the oil industry. Chapter 4, published in the *Economic Journal* in 1997, uses the model of irreversible investment developed earlier to appraise UK PRT; it is judged to be relatively neutral in its effects on development and fairly efficient in extracting rents. PRT was abolished in 1993 however, leaving revenues to be collected largely through standard corporation tax. This may be fine when oil prices are low; but what if they increase substantially? To answer this question, Chapter 5 considers state contingent reimposition of PRT, and finds that neutrality properties are impaired because of the incentives to bring development forward when prices are below the threshold for PRT. One way of avoiding such preemptive behaviour is to implement a stable tax regime. Another would be to switch to system of revenue raising by the auction of licenses.

Chapter 6 considers how auction may be designed to combine raising revenue up-front and sharing net revenues as the project evolves. In the straightforward price bidding case, the government sets the share of net revenues transferred to the oil companies (roughly 1 minus PRT rate), and the companies bid for the fields. It is shown however, that a more efficient mechanism is for the government to fix an up-front fee and for the companies to self-select the rate of PRT --- formally there is an open descending bid auction where the agents bid shares of the net revenues they would generate. Chapter 7 considers the situation where two oil fields are to be sold to the separate buyers, but there are production externalities. The optimal mechanism essentially charges the winning bidders the value of these externalities.

Part 3 Review and proposals

Chapter 8 considers both exploration (stage 1) and development (stage 2), and combines price bidding and share bidding. At stage 1, companies bid for exploration licenses by price; while at stage 2, companies bid for development rights by shares. Thus at the exploration stage, companies do not share the profits with the government, but pay a fee for the license; while at the second stage, there is no further cash fee, but companies compete in offering the government the share of revenues, i.e., they self-select the rate of PRT.

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Outputs

(a) Publications, presentations and working papers:

By Martin Cripps and Norman Ireland

(1) “Optimal complementary auctions”, mimeo, Department of Economics, University of Warwick, 1999. (Submitted to journal.)

By Norman Ireland

(2) “Revenue-sharing-bidding auctions for when principals can’t make losses”, mimeo, Department of Economics, University of Warwick, 1999.

(3) “The role of selling mechanisms in extracting rents from North Sea oil and gas”, mimeo, Department of Economics, University of Warwick, 1999.

By Marcus Miller and Lei Zhang

(4) “Long term gas supply contract”, mimeo, Department of Economics, University of Warwick, 1997.

(5) “Optimal abandonment”, mimeo, Department of Economics, University of Warwick, 1997.

(6) “Oil development and anticipated taxes or how taxing pure rents can have real effect”, presented at the Financial Economic Workshop on “Real options”, organised by CEPR/ESRC/IFR. February, 1999. (Submitted to journal.)

By Lei Zhang

(7) “Neutrality and efficiency of petroleum revenue tax: a theoretical assessment”, *Economic Journal*, 107(443), 1106-20, 1997.

(b) Book in draft form

“Developing North Sea Oil: Investing under Uncertainty”, edited by Lei Zhang, Martin Cripps, Norman Ireland and Marcus Miller.

Impacts

The Labour Government in the UK did consider carrying out a review of tax policy for North Sea oil and gas operations. Warning voices of the oil companies were heard to the effect that higher tax rates would mean lower investment, fewer jobs and possibly even lower tax revenue. Further to the March 1997 Budget, submissions from interested parties were invited in July 1997 with a view to possibly changing the regime in early 1998, but with the fall in oil prices, nothing further came of this. There is no disguising that this was a serious setback for a project designed to come with proposals for taxing oil rents. Simulations carried out by the Inland Revenue with oil prices below \$20 a barrel for peak production showed no PRT liability! Our research on taxation and the auctioning of licenses was continued nevertheless.

The recent rise of oil prices to around \$30 a barrel may well have rekindled political interest in specific taxation of oil profits. Moreover, the successful auctioning of spectrum licenses by the current government offers a valuable practical demonstration of another mechanism for raising revenue. We hope to tap this renewed interest by publishing a book containing the

research results of this project (together with some basic earlier material) updated in the light of high oil prices and real life auctions.

Future Research Priorities

Time consistency---the Devereux hypothesis

To what extent is the end of PRT predictable given that the government has to hand back taxes to offset abandonment expenditures.

Realistic simulations with current high oil prices

Further collaboration with Inland Revenue to investigate the effect of high oil prices by simulations.

Learning from experience of current auctions.

In particular, the spectrum auctions have led the way in designing implementable mechanisms for multi-unit allocations.

Further developing theoretical analysis to include

- (a) risk aversion by oil companies;
- (b) joint bids by oil companies;
- (c) formation of development consortium.

3. Significant Achievements:

- (i) Explicit proposals for reforming North Sea fiscal regime which show how competition may be introduced into the allocation of oil and gas resources by the use of auctions. The two auction proposals involve alternative mechanisms: *price bidding* with financial payments up-front, and *share bidding* which avoids initial financial outlay. Each of these may be combined with PRT (or RRT). Indeed share bidding is a form of field specific PRT.
- (ii) Auction results for price bidding versus share bidding. A paper showing greater efficiency of share bidding relative to price bidding in given circumstances.
- (iii) Auction results for connected fields. A paper showing how production externalities in connected field may be handled in the design of auctions.
- (iv) Non-neutrality results for PRT. A paper showing how price contingent reintroduction of neutral PRT is not neutral.
- (v) The value of guarantees and risk aversion. A paper showing how strongly risk aversion raises the value of floor price contracts for oil and gas.